Geostationary Operational Environmental Satellite (GOES)

GOES-R Series

Interface Requirements Document (IRD)

Space Segment (SS)
To
Emergency Managers Weather Information Network (EMWIN)

Draft

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To verify the correct version of this document, please contact the GOES R Series Requirements Management Office on 301-286-7898

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1 Introduction

The Geostationary Operational Environmental Satellite Series R (GOES-R) System will provide an expanded capability series of spacecraft to follow those developed and launched under the GOES N-Q Program. The expanded capabilities will follow from anticipated developments of the payload instrument suites as well as the several ancillary services included in the program mission. Six GOES-R Mission Segments interface and function to support the total GOES-R mission. They are:

- **Space Segment (SS)**
- Launch Support Segment (LSS)
- Ground Located - Command, Control, and Communications Segment (GL-C3S)
- Product Generation and Distribution Segment (PGDS)
- User Interface Segment (UIS)
- Archive Segment (AS)

As part of the Space Segment (SS), the GOES-R will support several NOAA auxiliary services:

- GOES Rebroadcast (GRB) Service
- Low Rate Information Transmission (LRIT) Service
- **Emergency Managers Weather Information Network (EMWIN) Service**
- Data Collection System (DCS)
- Search and Rescue (SAR) Service

1.1 Purpose

The purpose of this document is to describe and specify the functional and performance interface requirements for the communication links between the GOES-R Space Segment (SS) and the Emergency Management Weather Information Network (EMWIN).
This document it also intended to provide a basis for the subsequent development of a SS-EMWIN Interface Control Document (ICD).

1.2 Scope

The interfaces addressed in this document support the flow of data to and from the SS and the EMWIN ground segments. The EMWIN transponder in the GOES-R Series spacecraft (i.e., an element of the SS) performs a downconversion of the uplink S-Band signal to the downlink L-Band frequency. Therefore a complete characterization of the EMWIN links depends on the detailed process of onboard reception and retransmission. Only those parameters, which are necessary to specify the interface requirements, will be referenced here; additional specifications for the satellite transponder will be contained in a satellite performance specification. This IRD therefore:

- Identifies required RF links between the SS and the EMWIN ground segment
- Establishes functional and performance requirements related to these links.

1.3 Document Overview

This document contains five sections and two appendices.

Section 1 explains the purpose and scope of the IRD. It contains a list of applicable and reference documents relevant to the interface.
Section 2 describes the EMWIN system functional elements that must be supported by the subject interfaces.
Section 3 contains describes the characteristics of the EMWIN relevant to the interface with the GOES-R Space Segment. It describes the relevant characteristics of the EMWIN User Terminals (EUT's) for receiving and the CDAS for transmitting.
Section 4 provides the functional and performance requirements that must be met by the SS to support the link interfaces.
Section 5 specifies the overall link performance that must be met under specified assumptions.
Section 6 lists "To Be Determined" (TBD) and "To Be Reviewed" (TBR) parameters and issues in the IRD.
Section 7 lists abbreviations and acronyms used in the IRD.
The following document is relevant for this EMWIN interface requirement specification. It is intended that this IRD be read together with the relevant sections of the Satellite Performance Specification.

1.4 Reference Documents

The following documents [1] through [3] contain information about the EMWIN Service.
[1] Performance Specification for the GOES-N,O,P,Q, S-415-22, Attachment B, Table 10, 27 August 1997, NASA/GSFC]
[2] GOES N-Q Space-to-Ground Interface Control Document, Doc. No. DS80667-H00-003, Version 1.0, 31 March 1999
The following document contains information about the capabilities of the NOAA Command and Data Acquisition Stations (CDAS):
[3] NOAA/NESDIS Antennas and RF System Capabilities Handbook, NOAA/OSD3-2001-0043R0UD0, 10 August 2001

Additional information is available on the Internet NOAA Web page at http://iwin.nws.noaa.gov/emwin/index.htm

2 Emergency Managers Weather Information Network (EMWIN) and Interface Description

2.1 General Description

The Emergency Managers Weather Information Network (EMWIN) data will be transmitted from the NOAA Command and Data Acquisition Stations (CDAS) at Wallops, VA (or its backup) to the spacecraft for distribution to a large data user community. These ground terminals are referred to as EMWIN User Terminals (EUTs). The GOES support to the EMWIN user terminals is provided by GOES satellites located over Pacific and Atlantic. The EMWIN link relays emergency management weather information from the CDAS, independently through the GOES-East and GOES-West satellites, and downlinks to EMWIN user terminals. These are processed onboard the satellite by a separate EMWIN transponder.

Satellite EMWIN transponder is bent-pipe, i.e., receiving the uplinks within a certain frequency band, translating to a new frequency band, amplifying, and retransmitting on the downlink, but with no other processing. For the EMWIN link, the uplink is S-Band and the downlink is L-Band. Each satellite employs an antenna for reception of the uplink EMWIN signals and an earth coverage antenna to provide a downlink L-Band relay to the ground terminals. The EMWIN User Terminals may be anywhere in the earth coverage area of the satellite out to the design minimum elevation angle.
The EMWIN transmissions use two channels, designated GOES-East and GOES-West. Figure 2.1-1 shows the SS-to-EMWIN interface. The required connectivity through the GOES-R Series satellites is shown in Figure 2.1-2. Not shown in this figure are other links that support downlinking of the instrument data (Sensor Data or SD) and the transponder support to the other auxiliary services.

Figure 2.1-1: SS-to-EMWIN Interface Diagram

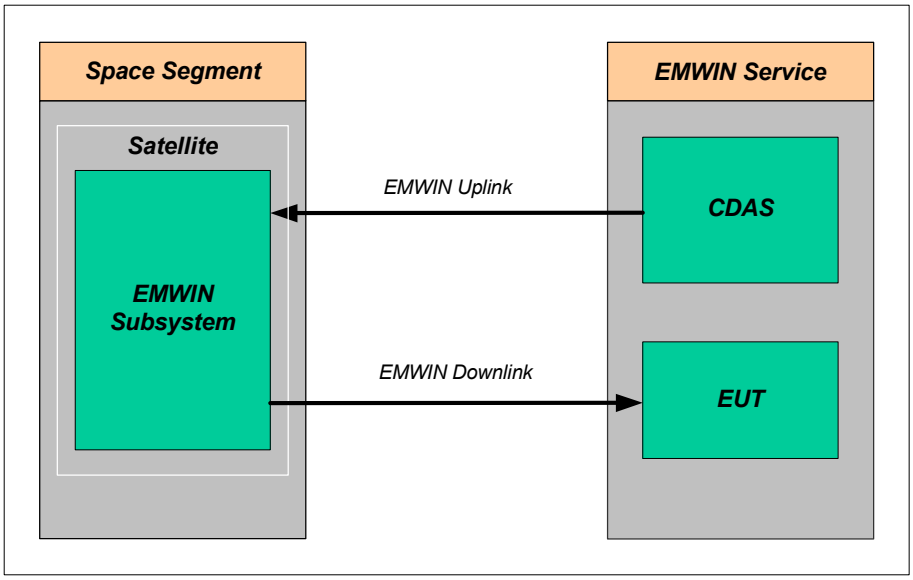
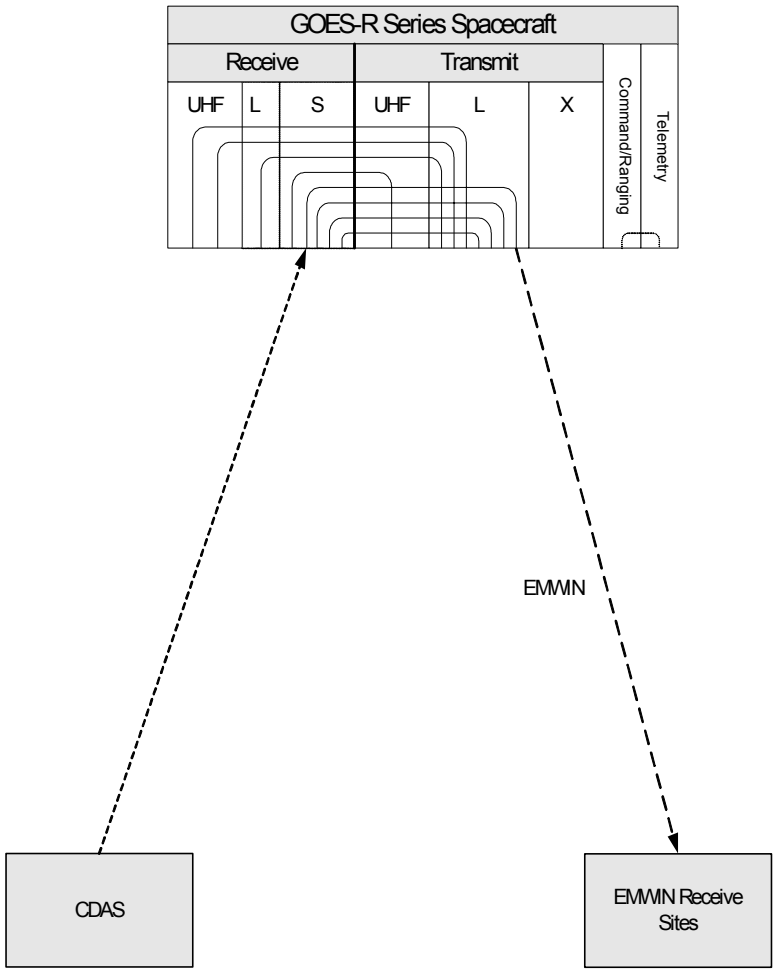


Figure 2.1-2: EMWIN Connectivity through GOES-R Series Satellites



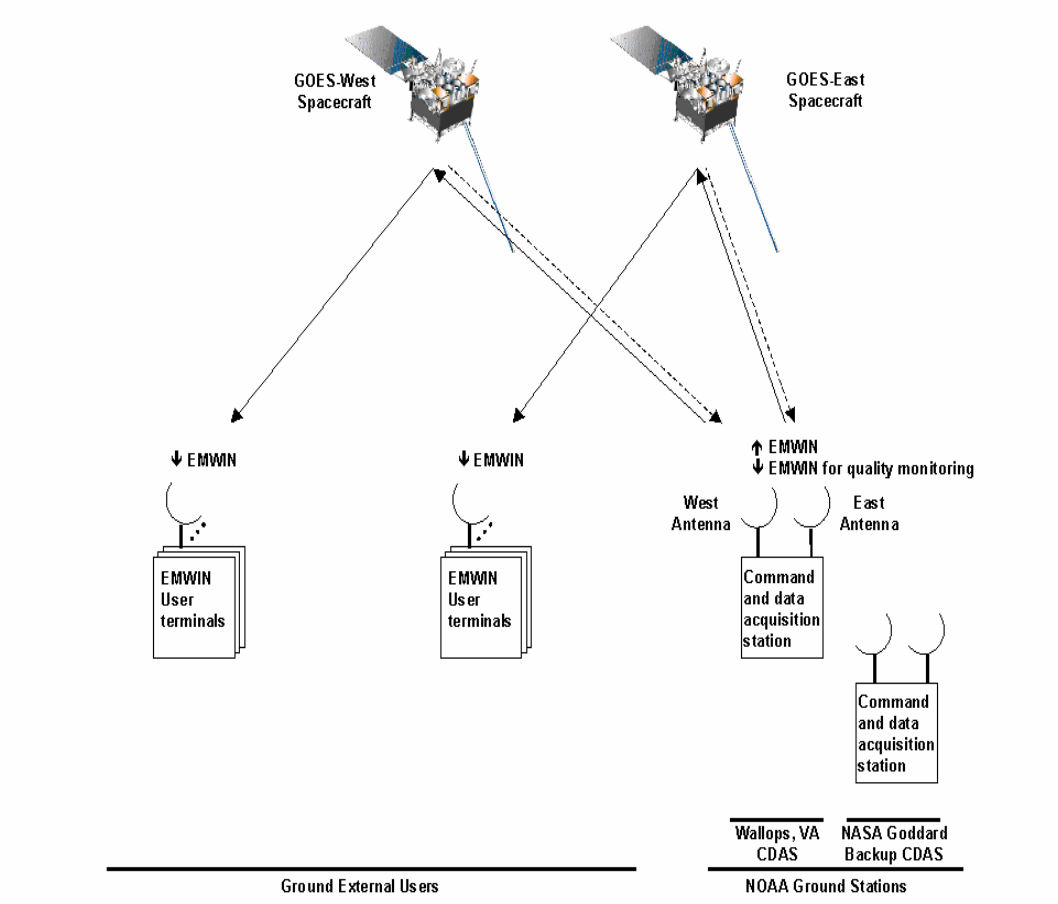
2.2 Interface Identification

Table 2.2-1 and Figure 2.2-1 illustrates the EMWIN interfaces between the GOES R satellites, CDAS, and EMWIN user terminals.

Table 2.2-1: EMWIN Interface Identification

Parameter	Value
Modes of operation	Broadcast EMWIN information
NOAA ground stations	CDAS at Wallops, VA CDAS-West antenna CDAS-East antenna Backup CDAS-E at NASA Goddard Backup CDAS-W at Fairbanks, Alaska
GOES-R satellite transponder	GOES-East EMWIN transponder GOES-West EMWIN transponder
Types of ground terminals	EMWIN User Terminals

Figure 2.2-1: EMWIN Interface Block Diagram



2.3 Interface Description

EMWIN service makes available a live stream of weather and other critical emergency information. As an integral part of its mission, the NWS recognizes the need to provide the emergency management community with access to a set of NWS warnings, watches, forecasts, and other products at no recurring cost. In partnership with the Federal Emergency Management Agency (FEMA) and other public and private organizations, EMWIN is currently a fully operational and supported NWS service.
The GOES-R Series satellites each provide a transponder for this new digital broadcast from the CDAS to EMWIN user terminals.

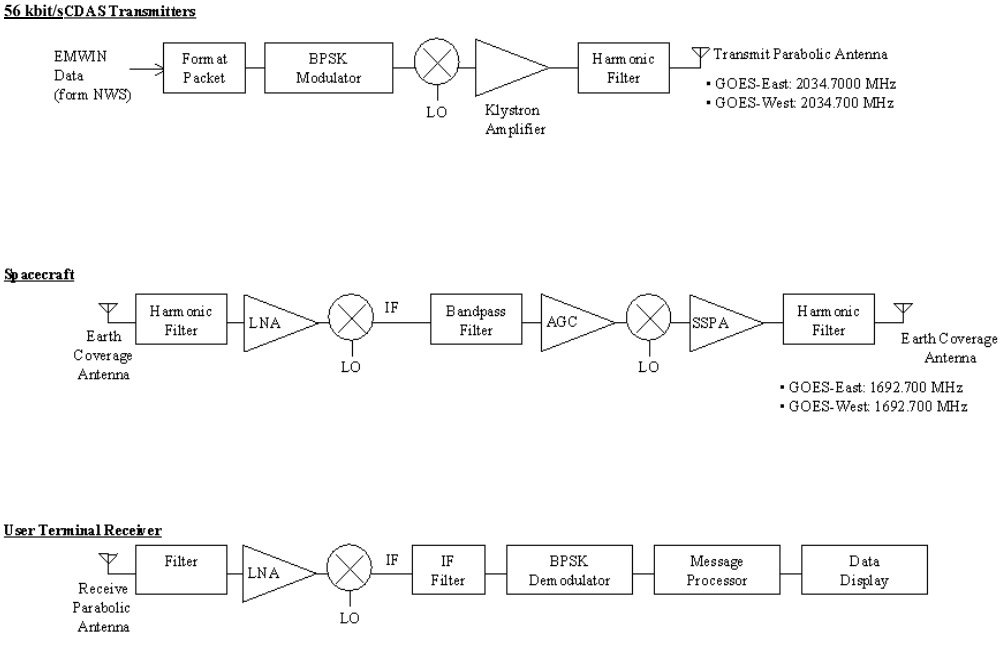
2.4 Functional Interface Requirements

Table 2.4-1 summarizes the EMWIN functional interface requirements between the GOES-R Series satellites, CDAS, and EMWIN User Terminals. Figure 2.4-1 illustrates the signal processing flow through the CDAS, satellites, and EMWIN user terminals.
The CDAS transmits the two independent EMWIN message streams using the CDAS-West and CDAS-East antenna systems. The CDAS encodes data, generates BPSK modulated signals, converts to S band, and transmits the signals to the satellites via identical uplink frequencies.
The uplink signals pass through the ground to space channel where they experience path loss, rain loss, and gaseous attenuation. Typically the CDAS-West and CDAS-East 16.4-meter parabolic antennas are pointed with approximately 15° and 46° elevation angles to the GOES-West and GOES-East satellites, respectively. Five degree elevation is used for a worst case link budget to accommodate scenarios where a GOES satellite is repositioned to a new or temporary orbital slot.
The GOES satellite receives the signal via an S band Earth coverage antenna, translates the center frequency to L band, and retransmits it via linearly polarized Earth coverage antenna. Both GOES-East and GOES-West use the same center frequency.
The downlink signals pass through the space to ground channel where they experience path loss, rain loss, gaseous attenuation, and scintillation effects. The EMWIN user terminals can reside anywhere in the Earth coverage antenna pattern. The link budget assumes the worst case elevation angle.
EMWIN user terminals receive the signal via a linearly polarized L band parabolic antenna, demodulate the data, decode and process message packets for viewing by users.

Table 2.4-1: EMWIN Functional Interfaces

Parameter	Value
Types of channels	One 56 kbit/s (user data rate) channel
Max number of channels for two satellites	Two; GOES-East and GOES-West
Max number of channels for one satellite	One
Channel access	TDM for one satellite, Ground station antenna diversity between satellites

Figure 2.4-1: Signal Processing Flow



2.5 Physical Interface Specifications

This section contains the uplink and downlink physical interface requirements between the GOES R satellites, CDAS, and EMWIN user terminals.

2.5.1 UpLink Parameters

Tables 2.5.1-1, -2, and -3 summarize the EMWIN uplink interface requirements from the CDAS to a GOES satellite.

Table 2.5.1-1: EMWIN UpLink Parameters - NOAA CDAS

Parameter	Value
Ground Transmitter	
Transmitter station location	CDAS at Wallops, VA and backup CDAS at NASA Goddard
User data rate	56 kbit/s
Error correction	Turbo Product Code rate 0.724 (TBR), equivalent to AHA4522
Center frequency	2032.7 MHz

Table 2.5.1-2: EMWIN UpLink Parameters - Channel

	Parameter	Value
	Uplink channel	
A	Uplink ground antenna elevation angle	> 5° 15.2° for CDAS-West 46.1° for CDAS-East
B	Topocentric range (km)	41,100 km for 5° elevation 40,000 km for 15.2° CDAS 37,300 km for 46.1° CDAS 35,800 km for 90° subnadir
C	Rain model and region	Crane region D2
D	Rain and atmospheric attenuation loss (dB)	0.40 dB
E	Up-link Modulation Sidelobe level (dBc)	< -30 dBc (below the peak of the main modulation lobe at the antenna input)

Table 2.5.1-3: EMWIN UpLink Parameters - Satellite

Parameter	Value
Satellite Receiver	
Center frequency (MHz)	2032.7 MHz
Antenna coverage	Earth coverage
Antenna polarization	Linear N-S

2.5.1.1 Commandable Gain

A command capability to limit the spacecraft EIRP **shall** be provided.

2.5.2 Downlink Parameters

Tables 2.5.2-1, -2, and -3 summarize the EMWIN downlink interface requirements from the GOES R satellites to EMWIN user terminals.

Table 2.5.2-1: EMWIN Downlink Parameters - Satellite

	Parameter	Value
	Satellite Transmitter	
A	Downlink frequency stability	$< \pm 1 \cdot 10^{-9}$ when measured over a 0.25-second interval, $< \pm 3 \cdot 10^{-6}$ long-term (mission design life)
B	Antenna coverage	Earth coverage
C	Antenna polarization	Linear N-S
D	Total EIRP (dBmi)	52 dBmi (TBR, it shall be the maximum possible subject to PFD limitations}
E	Sidelobe level (dBc)	< -20 dBc (TBR)

Table 2.5.2-2: EMWIN Dowlink Parameters - Channel

	Parameter	Value
	Downlink channel	
A	Downlink ground antenna elevation angle	> 5°
B	Topocentric range (km)	41,100 km for 5° elevation 35,800 km for 90° subnadir
C	Rain model and region	Crane region H
D	Rain and atmospheric attenuation loss (dB)	0.40 dB

Table 2.5.2-3: EMWIN Downlink Parameters - Ground External User

	Parameter	Value
	Ground Receiver	
A	Receiver station locations	Anywhere on the Earth within satellite coverage (antenna elevation angle ≥ 5°)
B	Center frequency	1692.7 MHz
C	Demodulation	BPSK
D	Error correction decoder	In Table 2.1.4.1-1
E	User data rate (kbit/s)	In Table 2.1.3-1

2.6 End-to-End Link Performance Parameters

Table 2.6-1 summarizes the EMWIN end-to-end link performance requirements between the CDAS, GOES R satellites, and EMWIN user terminals.

Table 2.6-1: EMWIN End-to-End Link Performance Parameters

Parameter	Value
Required end-to-end BER	$1 \cdot 10^{-8}$
Distortion impacts:	
Ground segment loss (dB)	≤ 2.3 dB (TBR)
End-to-end system margin (dB)	minimum worst case end-of-life link margin is 3 dB
Data link availability	99.9%, worst month

2.7 Data Link Interface Specifications

[TBD - The data packet formats are not yet defined]

3 EMWIN User Terminal (EUT) and CDAS Requirements

3.1 EMWIN User Terminal (EUT) Receive Requirements

The EMWIN User Terminals are L-Band receive-only terminals.

3.1.1 Receive Frequency Band

The nominal receive center frequency is 1692.7 MHz. The receive bandwidth is approximately 160 kHz.

3.1.2 Data Rate

The user data rate is 56 kbit/s.

3.1.3 G/T

The EMWIN User Terminal G/T **shall** be a minimum of -0.3 dB/K. This includes any antenna mispointing. Tracking is not required.

3.1.4 Receive Polarization

The antenna polarization **shall** be linear North-South (N-S) with a minimum cross-polarization discrimination of 20 dB [TBR].

3.1.5 Demodulation

The EUT **shall** be capable of BPSK demodulation of the received satellite signals.

3.1.6 Forward Error Correction

Forward error correction **shall** be included in the receive decoder to match the uplink Turbo Product Code Rate-0.724 (TBR) (AHA4522 or equivalent)

3.2 CDAS Requirements

3.2.1 Transmit Frequency

The uplink transmit nominal center frequency from the CDAS is 2032.7 MHz.

3.2.2 Data Rate

The user data rate is 56 kbit/s. The channel or transmission rate is approximately 56 · (1/ 0.724) or 77 kbit/s.

3.2.3 Transmit EIRP

The nominal EIRP for the uplink EMWIN signal from the Wallops CDAS is 81 dBmi [TBR].

3.2.4 Transmit Polarization

The transmit polarization is linear North-South, aligned with the identical polarization of the satellite. The minimum cross-polarization discrimination is 27 dB.

3.2.5 Modulation

The uplink **shall** be modulated using BPSK.

3.2.6 Forward Error Correction

The uplink **shall** use a Turbo Product Code Rate-0.724 (TBR) forward error correction (AHA4522 or equivalent)

4 Space Segment (SS) Requirements

The Space Segment (SS) requirements consist of receiving the uplink S band signal, downconverting to L-Band, amplifying and transmitting this signal to the EMWIN User Terminals. There is no demodulation of the EMWIN signals on the satellite and the gain is adjustable by ground command but without AGC (i.e., the transponder is 'bent-pipe').

4.1 CDAS-to-SS UpLink Interface

4.1.1 Frequency Band

The uplink frequency band is a nominal 250 kHz bandwidth with the nominal center frequency at 2032.7 MHz.

4.1.2 Satllite Receive G/T

The satellite receive G/T **shall** be -15 dB/K at edge of coverage (EOC).

4.1.3 Satellite Receive Antenna Coverage

The satellite receive antenna coverage **shall** be earth coverage with the minimum elevation angle of 5º.

4.1.4 Satellite Receive Antenna Polarization

The satellite receive antenna polarization **shall** be linear N-S with a minimum cross-polarization isolation of 27 dB [TBR] over the specified coverage area.

4.2 SS-to-EMWIN User Terminal Downlink Interface

4.2.1 Frequency Band

The downlink nominal center frequency is 1692.7 MHz. The required bandwidth **shall** be adequate to support the spectrum of the uplink signal, approximately 160 kHz [TBR].

4.2.2 Satellite EIRP

The downlink EIRP **shall** be 52.0 dBmi [TBR] over the required coverage area at end of satellite design life.
It **shall** be the maximum possible subject to PFD limitations.
To satisfy power flux density limits, the downlink maximum EIRP **shall** be adjustable downward from the maximum in 1 dB steps by a minimum range of 8 dB as commanded from the GL-C3S.

4.2.3 Satellite Transmit Antenna Coverage

The downlink satellite transmit antenna coverage **shall** be earth coverage to the minimum elevation angle of 5º.

4.2.4 Satellite Transmit Antenna Polarization

The downlink satellite transmit antenna polarization **shall** be linear N-S with a minimum cross-polarization isolation of 27 dB [TBR] over the specified coverage area.

5 Link Performance Specification

Based on the assumed link parameters of Section 5.1, the link performance **shall** meet the performance criteria of Sections 5.2 and 5.3. Performance is specified for the combined up and downlinks, i.e., for the full path between CDAS antenna and EUT.

5.1 Link Assumptions

The link calculations **shall** demonstrate link closure under the following assumptions.

1. FEC equivalent to a Turbo Product Code of Rate 0.724 **shall** be assumed
2. A ground segment (EUT) loss of 2.3 dB [TBR] **shall** be assumed
3. Scintillation losses **shall** be considered to be 1.5 dB [TBR] for both the up and downlinks; however, it may be assumed that scintillation occurs independently on the up and downlinks and is not simultaneous.
4. Worst-case polarization mismatches on the uplink and downlink **shall** be assumed.

5. Interference accesses **shall** be assumed small and no specific entry is required.
6. Rain and atmospheric loss **shall** be calculated for an assumed Crane region D2 for the uplink and Region H for the downlink.
7. Minimum end-of-life link margin **shall** be 3 dB.

5.2 Link Availability

The link availability **shall** be 99.9%, worst month or better under the assumptions of Section 3.1, defining the ground receiver quality.

5.3 Link Bit Error Rate

The end-to-end link bit error rate (BER) **shall** be $1 \cdot 10^{-8}$ or better under the assumptions of Section 5.1.

6 TBR/TBD Listing

Number (SS/EMWIN)	Description	Resolution Plan	Date
TBR/TBD1	§5.1.2, nominal signal level	Analysis/Review by CWG	
TBR/TBD2	§5.1.4, satellite receive G/T	Analysis/Review by CWG	
TBR/TBD3	§5.1.5, satellite receive antenna minimum elevation angle	Analysis/Review by CWG	
TBR/TBD4	§5.1.6, satellite receive antenna axial ratio	Analysis/Review by CWG	
TBR/TBD5	§5.2.2, satellite EIRP	Analysis/Review by CWG	
TBR/TBD6	§5.2.3, satellite transmit antenna minimum elevation angle	Analysis/Review by CWG	
TBR/TBD7	§5.2.4, satellite transmit antenna axial ratio	Analysis/Review by CWG	
TBR/TBD8	§6.1 (1), CDAS EIRP	Analysis/Review by CWG	
TBR/TBD9	§6.1 (2), uplink propagation impairments	Analysis/Review by CWG	
TBR/TBD10	§6.1 (2), downlink propagation impairments	Analysis/Review by CWG	
TBR/TBD11	§6.1 (3), minimum elevation angles at CDAS and EUT	Analysis/Review by CWG and COSPAS/EMWIN SAT	
TBR/TBD12	§6.2, link availability	Analysis/Review by CWG	
TBR/TBD13	§6.3, link BER	Analysis/Review by CWG	
TBR/TBD14			
TBR/TBD15			
TBR/TBD16			
TBR/TBD17			
TBR/TBD18			
TBR/TBD19			
TBR/TBD20			
TBR/TBD21			
TBR/TBD22			
TBR/TBD23			

CWG = GOES-R Communications Working Group

7 Abbreviations and Acronyms

AGC	Automatic Gain Control (functionally equivalent to ALC)
ALC	Automatic Level Control (functionally equivalent to AGC)
AM	Amplitude Modulation
AS	Archive Segment
β	Modulation Index
BCH	Bose-Chaudhuri-Hocquenghem (Forward Error Correction Code)
BER	Bit Error Rate
BPSK	Binary Phase Shift Keying
BW	Bandwidth or Beamwidth (context dependent)
C3S	Command, Control and Communications Segment
CDA	Command and Data Acquisition
CDAS	Command and Data Acquisition Station
CCSDS	Consultative Committee on Space Data Systems
C/N_0	Carrier to Noise Density Ratio (dB-Hz)
COSPAS	(Russian: Cosmicheskaya Sistyema Poiska Avariynich Sudov) Space System for the Search of Vessels in Distress
CP	Circularly Polarized or Circular Polarization
DCS	Data Collection System
EIRP	Equivalent Isotropically Radiated Power
EOC	Edge of Coverage
EUT	EMWIN User Terminal
EMWIN	Emergency Managers Weather Information Network
EPIRB	Emergency Position Indicating Radio Beacons
GEOLUT	Geostationary Local User Terminal
GL-C3S	Ground Located C^3 (Command, Control, and Communications) Segment
GOES	Geostationary Operational Environmental Satellite
GRB-F	GOES Rebroadcast - Full
GRB-L	GOES Rebroadcast - Lite
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
G/T	Gain-to-Noise Temperature Ratio (dB/K)
ICD	Interface Control Document
IRD	Interface Requirements Document
ITU	International Telecommunications Union

L-Band	1.5 - A1.6 GHz Frequency Band
LEO	Low Earth Orbit
LHCP	Left Hand Circularly Polarized
LP	Linearly Polarized or Linear Polarization
LRIT	Low Rate Information Transmission
LSS	Launch Support Segment
LUT	Local User Terminal
MCC	Cospas-EMWINsat Mission Control Center
NASA	National Aeronautics and Space Administration
NOAA	National Oceanographic and Atmospheric Administration
PGDS	Product Generation and Distribution Segment
PLB	Personal Locator Beacon
PM	Phase Modulation
PSK	Phase Shift Keying
RF	Radio Frequency
RHCP	Right Hand Circularly Polarized
RVTM	Requirements Verification Traceability Matrix
EMWIN	Search and Rescue
EMWINSAT	Search and Rescue Satellite-Aided Tracking
S-Band	2.5 - 2.7 GHz Frequency Band
SS	Space Segment
TBD	To Be Determined
TBR	To Be Reviewed
TBS	To Be Supplied
TRD	Technical Requirements Document
UHF	300 - 1000 MHz Frequency Band
UIS	User Interface Segment
USG	United States Government
X-Band	8 - 12 GHZ Frequency Band